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PERFORMANCE OF ACID-ADAPTIVE SOYBEAN EXPECTED LINES IN SOUTH LAMPUNG, INDONESIA

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ABSTRACT

Acid soil area is one of the areas broadly available in Indonesia. However, the complexity of acid soil may lead to low soybean productivity. Hence, soybean variety which is adaptive to acid soil is needed. The objective of this research was to find out expected lines adaptive to acid soil. A number of ten soybean lines and two check varieties were grown in Natar Research Station in dry season II, 2011. This research applied randomized completely block design with four replications. Results showed that 7 of 10 soybean lines had grain yield higher than those of two check varieties. The three lines with the highest grain yield were Tgm/Anj-957, Tgm/Anj-908 and Tgm/Anj-932 with grain yield 1.83, 1.74, and 1.65 t ha^{-},^{1} respectively. Tanggamus variety had grain yield higher than Wilis. The highest grain yield line, Tgm/Anj-957, was also supported by the highest number of pods per plant up to 68 pod. Line of Tgm/Anj-995 was the line with the largest seed size, i.e. 16 g per 100 seeds.

Keywords: acid soil, expected lines, *Glycine max*, yield

INTRODUCTION

Increasing soybean demand is not able to be fulfilled by domestic production, and lead the increasing soybean import. The decline in soybean production was mainly due to a decrease in harvesting area up to 8.04% in the period of 1994-1997 and 7.91% in the period of 1997-2006 (Supadi, 2009 and Zakaria, 2010). The decreasing of harvesting area in Java Island is due to the land conversion of agricultural land into non-agricultural land. Hence, the expansion of harvesting area should be conducted outside Java Island. However, the lands outside Java Island are usually a suboptimal land that has soil fertility problems. One suboptimal land is dry land which covers 102,817,113 ha. This means that approximately 69% of dry land in Indonesia is acid soil (Mulyani, 2006).

The problem in acidic soil can be divided into two groups, namely micro nutrients toxicity (Al and Mn) and macro nutrients defficiency (N, P, K, Ca, Mg and Mo) as well as the detrimental effect of H^+ ion. In addition, the population of beneficial micro-organisms such as nitrifying bacteria is also low (Kresović *et al.*, 2010). Soil acidity can be corrected by liming which aims to increase crop production, but it is not be able to be applied economically to soybean farming for farmers with low income levels (Uguru *et al.,* 2012). Therefore, it is needed some alternative ways to increase crop production on acid soils.

Genetic improvement of plant adaptation to soil acidity is an approach that is inexpensive and easy to be implemented. Research activities have been carried out, from the development of

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screening techniques in the laboratory (Liao *et al.,* 2006; Villagarcia *et al.,* 2001), screening germplasm in laboratory (Ojo and Ayuba, 2012a; 2012b) and screening germplasm in the field (Ojo *et al*., 2010); genetic studies (Kuswantoro *et al.,* 2011;Ojo and Ayuba, 2013), development of molecular markers (Tasma and Warsun, 2009), gene expression (Duressa *et al.,* 2011), selection of segregating populations (Spehar and Souza, 2006), response of genotypes (Uguru *et al.,* 2012) and genetic gain (Kuswantoro *et al.,* 2013). The study of adaptation mechanisms involving soybean phosphorus absorption in acidic soil also has been done (Bertham and Nusantara, 2011). Basically, the above studies refer to changes in the expression of soybean genotypes in the targeted environment, in this case soil acidity.

Performance of a plant in an environment is a result of the genetic and the environment factors. Ussually, different environment lead different performance of a genotype, but some genotypes can have similar performance in different environment. Therefore, the genetics expression of a phenotype depends on its environment. The phenotype of a genotype is not necessarily the same when the agro-ecological conditions are different (Ali *et al.,* 2003).

In a breeding program, performances of genotypes across environments is conducted to find out stable genotypes. Hence, testing some genotypes in diverse environments is critical to ensure that the selected genotypes have acceptable appearance in a different environment in the targeted areas, testing the diverse environment is essential (Ashraf *et al.,* 2010). In this study, the aim of the research was to evaluate the soybean expected lines in acidic soil of South Lampung, where the soil properties is relatively similar in this area. Therefore, the result of this study is expected to obtain acid-adaptive soybean expected lines in an area with the similar soil properties of South Lampung.

MATERIALS AND METHODS

A total of 10 soybean lines and two check varieties (Wilis and Tanggamus) were grown in acid soil of South Lampung. The tested soybean lines are the result of a crossing between varieties of Tanggamus and Anjasmoro. Tanggamus is soybean varieties with good adaptation ability in acid soil, while Anjasmoro is a variety with large soybean seed.

The experiment was conducted at Natar Research Station, South Lampung in Rainy Season II 2011. Randomized completely block design was used with four replications. Plot was made with the size of 2.4 m × 4.5 m with plant spacing of 0.4 m × 0.15 m, two plants per hill. Soil tillage was applied by plowing the soil, and it was leveled with a rake. Fertilizer was done by applying 50 kg Urea, 75 kg SP36 and 75 kg KCl per hectare at sowing time. Weeding was carried out in 2 and 4 weeks after planting (WAP) to prevent excessive growth of weeds. Pests and diseases were intensively controlled by monitoring their existence. Harvesting was conducted after the crop was physiological matured, shown by yellowing or browning of the pods and falling of the leaves.

Variables measured for this experiment were 50% days of flowering age, maturity age, plant height, number of branches, number of reproductive nodes, number of pods, 100 seed weight and seed yield. Differences among the lines in each variable were tested using the F test at 5% significance level. Significantly different variables were then tested further by Least Significant Difference test (LSD). The entire statistical analysis was performed using PKBT Stat software.

RESULTS AND DISCUSSION

The results of analysis showed that the soybean lines were significantly different in all of the observed characters except plant height (Table 1). This suggests that there were differences among the tested soybean lines. Based on flowering character, the tested lines had an average 39 days with a range of 35-43 days (Table 2). Line having earliest flowering age was Tgm/Anj-931, and the latest flowering age was Tgm/Anj-910. There were four lines having earlier flowering age than the check variety of Tanggamus, namely Tgm/Anj-931, Tgm/Anj-932, Tgm/Anj-991, and Tgm/Anj-957. The check variety of Willis had 42 day flowering age, while the tested lines had average flowering age less than 40 days.

Table 1. Analysis of variance of agronomic characters of acid-adaptive soybean lines

Source of variation	df	FA	MA	PH	BRC	NODE	POD	W100	YIELD
Replication	3	0.31	1.33	251.35	0.28	9.31	267.68	0.47	0.05
Genotype	11	24.08**	8.24**	113.76	2.19*	48.54**	456.20**	15.87**	0.11*
Error	33	1.34	0.79	109.39	0.83	15.18	40.03	1.28	0.04
CV (%)		2.58	1.05	16.64	33.61	22.48	13.65	9.83	13.26

Remarks: **Significant at 1% level, *Significant at 5% level. FA = days to flowering, MA = days to maturing, PH = plant height, BRC = number of branches, NODE = number of reproductive nodes, POD = number of pods, W100 = weight of 100 seeds, YIELD = yield per hectare

Maturity of the tested lines averaged 84 days with a range of 81-86 days. Tgm/Anj-995 showed the earliest maturity age, while Tgm/Anj-931 showed the latest maturity age. The earliest mature line of Tgm/Anj-995 also showed earlier maturity age than the two check varieties. Generally, the tested lines had earlier maturity age than Tanggamus (86 days) and Willis (83 days) (Table 2). Adie (2007) classified the maturity age of Indonesian soybean as ultra early (<70 days), early (70-80 days), medium (80-85 days), late (86-90 days), very late (> 90 days). Therefore, the tested lines were classified as medium maturity age.

Table 2. Flowering and maturity age of acid-adaptive soybean lines

Lines	Days to flowering (days)	Days to maturing (days)
Tgm/Anj-933	39[def]	86[a]
Tgm/Anj-931	36[h]	86[a]
Tgm/Anj-910	44[a]	86[a]
Tgm/Anj-932	37[gh]	83[bc]
Tgm/Anj-909	38[efg]	84[b]
Tgm/Anj-991	37[gh]	84[b]
Tgm/Anj-957	37[fgh]	84[b]
Tgm/Anj-908	40[cd]	84[b]
Tgm/Anj-995	40[cde]	82[c]
Tgm/Anj-919	41[bc]	86[a]
Tanggamus	38[fg]	86[a]
Wilis	42[ab]	83[bc]
Average	39	84
LSD 5%	1.66	1.28

Remarks: Values followed by the same letters in the same column were not significantly different at LSD 5%.

The tested lines had average plant height of 62.83 cm with a range of 51.4 - 68.6 cm. The acid-tolerant variety Tanggamus showed plant height of 65.95 cm. There were four lines which had higher plant height than Tanggamus, namely Tgm/Anj-931, Tgm/Anj-991, Tgm/Anj-908, and Tgm/Anj-919. The broad adaptive variety of Willis had a plant height of 58.8 cm. There were four lines which had higher plant height than Wilis, namely Tgm/Anj-995, Tgm/Anj-957, Tgm/Anj-909, and Tgm/Anj-910 (Table 3). One of the selection criteria for acid-adaptive soybean lines is plant height. It is due to the vegetative growth of stressed plants which will be hampered by micro nutrient toxicity as well as macro nutrients deficiency (Kuswantoro *et al.,* 2013). Four lines having higher plant height also showed higher average seed yield (higher than Wilis).

The number of branches per plant averaged 2.7 with a range of 1.6 - 4.2. Check variety of Tanggamus has two branches and Willis has three branches. Lines which had higher than average branch and check varieties were Tgm/Anj-910, Tgm/Anj-932, Tgm/Anj-991, and Tgm/Anj-957. Tgm/Anj-957 line had the most branches with a mean number of 4.2 branches (Table 3). The number of branches followed by the number of reproductive nodes were expected to contribute to the yield. This was supported by Tgm/Anj-957 line that had the highest number of branches, and many number of reproductive nodes showed the highest pod number and seed yield than other lines. According to Wirnas *et al.* (2006), the number of branches is one of the agronomic traits that had positive and highly significant correlation with seed yield per plant in soybean. The number of branches belongs to a character that had high broad sense heritability values (Indriani *et al.,* 2012).

The number of reproductive nodes per plant averaged 17 and ranging 13 - 24. The check varieties of Wilis and Tanggamus had 19 and 16 reproductive nodes per plant, respectively. This number of reproductive nodes per plant was much more than those reported by Rauf (2010) implying that the number of reproductive Willis and Tanggamus only had 8 and 7 reproductive nodes, respectively. There were three lines having the number of reproductive nodes per plant higher than the check varieties, namely Tgm/Anj-910, Tgm/Anj-991, and Tgm/Anj-957. Line of Tgm/Anj-910 had the highest number of reproductive nodes per plant (Table 3).

Character of pods number is a supporting character to the weight yield per plot. This was demonstrated by Tgm/Anj-957 which had the highest number of pods and also the highest crop yields. According to Sumarno and Zuraida (2006), the total number of pods was positively correlated to seed weight per plant. In this study, the average number of pods per plant was 48 with a range between 25-68 pods. Lines of Tgm/Anj-957 and Tgm/Anj-991 had the number of pods per plant higher than the check varieties (Tanggamus and Wilis). Willis had 55 pods per plant and Tanggamus had 51 pods per plant (Table 4). In acidic soil Manokwari, Tanggamus could produce 995 – 114 pods per plant (Rauf, 2010). Generally, the tested lines had fewer numbers of pods than the check varieties. The small number of pods was due to the acidity of the soil as well as the less availability of water, where this condition is common in acid soil (Kuswantoro and Zen, 2013).

Weight of 100 seeds of soybean indicated seed size. Weight of 100 seeds of the tested lines averaged 11.53 g with a range of 10.16 to 16.00 g (Table 4). Tanggamus and Willis had weight of 100 seeds 8.45 and 9.39 g respectively. According to Adie and Krisnawati (2007), soybean is categorized as large (14 g per 100 seeds) medium (10-14 g per 100 seeds), and small (less than 10 g per 100 seeds). Therefore, Tgm/Anj-995 was classified as large seeded line and nine other lines were classified as medium seeded lines. However, all of ten tested lines showed larger seed size than the check varieties. Seed weight is one of the important agronomic traits for the tempeh industry, where they usually prefer large seed for making tempeh (Krisdiana, 2007).

Table 3. Plant height, number of branches and number of reproductive node of acid-adaptive soybean lines

Lines	Plant height (cm)	Number of branches per plant	Number of reproductive nodes per plant
Tgm/Anj-933	51.4^{b}	2.2^{cd}	15.1^{cd}
Tgm/Anj-931	67.5^{a}	2.2^{cd}	17.4^{bcd}
Tgm/Anj-910	62.6^{ab}	3.5^{abc}	24.5^{a}
Tgm/Anj-932	55.9^{ab}	3.2^{abc}	17.6^{bcd}
Tgm/Anj-909	63.9^{ab}	1.6^{d}	13.2^{d}
Tgm/Anj-991	67.4^{a}	3.6^{ab}	19.9^{abc}
Tgm/Anj-957	64.9^{ab}	4.2^{a}	21.9^{ab}
Tgm/Anj-908	67.4^{a}	2.5^{bcd}	15.1^{cd}
Tgm/Anj-995	60.2^{ab}	2.5^{bcd}	13.3^{d}
Tgm/Anj-919	68.6^{a}	2.3^{bcd}	15.1^{cd}
Tanggamus	66.0^{ab}	2.3^{bcd}	16.1^{cd}
Wilis	58.8^{ab}	2.7^{bcd}	19.2^{abc}
Average	62.8	2.7	17.3
LSD 5%	15.05	1.31	5.60

Remarks: Values followed by the same letter in the same column were not significantly different at LSD 5%.

Table 4. Number of pods, 100 seed weight and yield of acid-adaptive soybean lines

Lines	Number of pods per plant	100 seeds weight (g)	Yield (t ha^{-1})
Tgm/Anj-933	46.6[cde]	13.83[b]	1.51[bc]
Tgm/Anj-931	41.4[de]	10.99[cde]	1.55[abc]
Tgm/Anj-910	48.7[cde]	10.72[cde]	1.41[cd]
Tgm/Anj-932	49.4[cd]	10.16[de]	1.65[abc]
Tgm/Anj-909	39.7[e]	11.67[cd]	1.59[abc]
Tgm/Anj-991	59.8[ab]	12.35[bc]	1.61[abc]
Tgm/Anj-957	68.4[a]	10.89[cde]	1.83[a]
Tgm/Anj-908	48.3[cde]	11.86[c]	1.74[ab]
Tgm/Anj-995	25.0[f]	16.00[a]	1.47[bcd]
Tgm/Anj-919	48.5[cde]	12.05[c]	1.36[cd]
Tanggamus	51.4[bc]	9.39[ef]	1.47[bcd]
Wilis	54,7[bc]	8.45[f]	1.21[d]
Average	48,5	11.53	1.53
LSD 5%	9.10	1.63	0.29

Remarks: Values followed by the same letters in the same column were not significantly different at LSD 5%.

The average yield of genotypes per hectare was 1.53 t ha^{-1} with a range of 1.36-1.83 t ha^{-1}, while Willis and Tanggamus had 1.21 and 1.47 t ha^{-1} (Table 4). Yield potential of Tanggamus in acidic soil with two plants per hill reached 1.22 t ha^{-1}, while the averaged yield of Willis in optimal land was 1.6 t ha^{-1}. Seven lines had higher seed yield than the check varieties, i.e. Tgm/Anj-933, Tgm/Anj-931, Tgm/Anj-932, Tgm/Anj-909, Tgm/Anj-991, Tgm/Anj-957, and Tgm/Anj-908. Line of Tgm/Anj-957 showed the highest seed yield (1.83 t ha^{-1}), this line also had the highest number of pods. This indicated that number of pods contributed to the yield per plant, and lines with the highest yield showed an adaptation to acid soil condition. Character of seed yield had high broad sense of heritability (0.89) (Indriani *et al.,* 2012),meaning that genetic factors are more important than the environment.

CONCLUSION AND SUGGESTIONS

Seven lines had higher seed yield than the check varieties. Tanggamus varieties had higher yields than Willis. Line of Tgm/Anj-957 had the highest yield (1.83 t ha^{-1}) with the highest number of pods (68 pods). Line of Tgm/Anj-995 had the largest grain size (16 g per 100 seeds). The seven lines, especially Tgm/Anj-957, could be developed as acid-adaptive soybean in South Lampung.

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